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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 200.
B. T. GALLOWAY, *Chief of Bureau.*

BREEDING NEW TYPES OF EGYPTIAN COTTON.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., August 18, 1910.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 200 of the series of this Bureau the accompanying manuscript, entitled "Breeding New Types of Egyptian Cotton," by Mr. Thomas H. Kearney, Physiologist in Charge of Alkali and Drought Resistant Plant Breeding Investigations.

As a result of experiments that have been carried on for the past seven years in acclimatizing and breeding Egyptian cotton in the southwestern United States, several distinct types have originated from the stock of imported seed of the Mit Afifi variety with which the work was begun. Two of these are as distinct in the characters of the plants, bolls, and fiber as some of the newer varieties which have originated in Egypt from the Mit Afifi. A third promising type is an improved acclimatized strain of Mit Afifi rather than a new variety.

The principal object of the present publication is to describe the leading characteristics of these promising varieties and strains and the methods followed in the plant-breeding work. A brief account is also given of the general progress of the acclimatization experiments with Egyptian cotton during the year 1909.

The United States continues to import large quantities of staple cotton. In 1909 the imports from Egypt amounted to 72,617,893 pounds, valued at $12,101,000. Spinners who have examined samples of the acclimatized Egyptian fiber grown last year in the Southwest pronounce it to be in every way as well adapted to their requirements as imported cotton of corresponding grades.

The possibility of growing Egyptian cotton of good quality on the irrigated lands of southern Arizona and southeastern California has been demonstrated. Production on a large scale awaits the solution of certain cultural and commercial problems which are now receiving attention.

Respectfully,

G. H. Powell,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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BREEDING NEW TYPES OF EGYPTIAN COTTON.[a]

INTRODUCTION.

The work of the Bureau of Plant Industry with Egyptian cotton in the Southwestern States and Territories involves three closely related but somewhat distinct lines of investigation, as follows:

(1) Plant-breeding investigations, the object of which is to secure improved, high-yielding varieties and strains by the selection of superior individuals producing fiber which represents the best commercial types of Egyptian cotton. The present publication deals mainly with this phase of the work.

(2) Acclimatization investigations, the object of which is to study the diversity exhibited by imported and by more or less acclimatized stocks when planted under different environmental conditions, so as to ascertain what environments and what cultural conditions are most favorable to uniformity, fruitfulness, and the production of good lint in each stock.[b]

(3) The study of irrigation and other cultural methods for growing the crop and of industrial methods for preparing and marketing the product. These studies are directed by the officers of the Bureau of Plant Industry who are in charge of the cooperative

[a] The general results of the experiments with Egyptian cotton in the southwestern United States up to the end of the year 1908 were described in Bulletin 128 of the Bureau of Plant Industry, entitled "Egyptian Cotton in the Southwestern United States," and in Circular 29 of the same Bureau, entitled "Experiments with Egyptian Cotton in 1908," both publications being by Thomas H. Kearney and William A. Peterson.

[b] Some of the results of the investigations in this field by Mr. O. F. Cook and his assistants are described in the following publications of the Bureau of Plant Industry: Bulletin 147, entitled "Suppressed and Intensified Characters in Cotton Hybrids," by O. F. Cook, 1909; Bulletin 156, "A Study of Diversity in Egyptian Cotton," by O. F. Cook, Argyle McLachlan, and Rowland M. Meade, 1909; Circular 42, "Origin of the Hindi Cotton," by O. F. Cook, 1909; Circular 53, "Mutative Reversions in Cotton," by O. F. Cook, 1910.

work with the Reclamation Service and with the Office of Indian Affairs, respectively. Mr. W. A. Peterson, superintendent of the cooperative experiment farm of the reclamation project at Yuma, Ariz., and Mr. E. W. Hudson, superintendent of the cooperative experiment farm on the Pima Indian Reservation at Sacaton, Ariz., are in immediate charge of the cultural experiments. Most of the experimental work with Egyptian cotton in the Southwest has thus far been carried on at these two stations.

In 1909 the plant-breeding plats were located in the Yuma Valley [a] and at Sacaton, Ariz. In the Yuma Valley two fields were planted with bulk seed of the two most promising of the new types described later, four fields were each planted with imported seed of one of the Egyptian varieties, and various smaller experimental plantings were made. At Sacaton, in addition to the plant-breeding plat and the plats grown from imported seed of Egyptian varieties, a field of 10 acres was grown from mixed seed of the "bulk selections" made at Sacaton in 1908. In the Imperial Valley, California, small field plantings of four different types of the acclimatized stock were made, each in a different locality. Another of the acclimatized types was tested at Glendale, near Los Angeles, Cal., alongside a planting of newly imported seed of the Mit Afifi variety.

The results of the season's work were on the whole very encouraging. For the first time in the course of these experiments, fields of several acres each were planted to high-bred varieties and strains, each derived from a single individual plant selected in the breeding nursery only two years previously. A gratifying degree of uniformity in the plants and fiber was exhibited. The best three of these new types are described in detail in the present publication. Two of them, the "Yuma" and the "Somerton" varieties, are so distinct from the Mit Afifi variety, with which the breeding work was begun, as to warrant the assumption that they constitute mutations. The third (strain No. 361) is a typical Mit Afifi, but superior in yield, earliness, and quality of the fiber to plants grown from imported seed of that variety. This strain is apparently a product of acclimatization and selection without the aid of mutation.

The great amount of diversity that manifested itself in the experimental fields in 1908 was largely eliminated, partly as a result of planting these selected stocks and partly through the application of methods of "roguing" at an early stage in the development of the

[a] The experimental plantings in the Yuma Valley in 1909 were located near the village of Somerton, about 14 miles south of the town of Yuma. In 1910 most of the experimental work near Yuma is located on the new cooperative experiment farm situated on the California side of the Colorado River, about 7 miles above the town of Yuma.

plants which Mr. Cook has worked out as a result of his studies of diversity. Samples of the fiber produced at Somerton and Sacaton in 1909 were submitted to a number of buyers and spinners, who have given uniformly favorable reports on its quality. Comparisons with cotton of the corresponding grades imported from Egypt have invariably been favorable to the Arizona product.

NEW TYPES DEVELOPED.

The varieties and strains[a] of Egyptian cotton described in this paper were derived from a stock of seed of the Mit Afifi variety imported from Egypt by the Office of Seed and Plant Introduction and Distribution and tested at several localities in the Southwest in 1902.[b] They are all descended from individual-plant selections made in the field at Carlsbad, N. Mex., that was planted with this seed. In 1906 the surviving progenies of these selections were transferred to Yuma, Ariz., and since then the breeding work has been continued in that locality. In 1909 a plant-breeding nursery was started at Sacaton, Ariz., with seed of a number of individual selections from the progeny rows at Yuma of the previous year, in addition to seed of a number of individual selections made in 1908 in the 10-acre field at Sacaton.[c]

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[a] In this bulletin the term "variety" is applied to such of the new forms as can easily be distinguished from the original stock by their botanical characters. The two new varieties described are believed to have originated as mutations. Where the differences are simply of degree—greater fruitfulness, earlier ripening, longer and stronger fiber, etc.—and no evidence of mutation is shown, the term "strain" is employed.

[b] For an account of the earlier experiments, see Bulletin 128, Bureau of Plant Industry, United States Department of Agriculture, 1908, pp. 34–45.

[c] The field planting of 1908 at Sacaton was made with mixed seed from the 1907 breeding rows at Yuma. As would be expected, considerable diversity was noted among the plants in this field. A large number of individuals which were superior to the average in fertility and in fiber qualities and which appeared to be purely Egyptian in all their characters were marked and picked separately. The mixed seed from these plants was used for planting the "general field" at Sacaton in 1909, in order to ascertain the general fertility and state of acclimatization of the stock after the removal of all hybrids and other conspicuously inferior individuals and to afford a further opportunity for the selection of desirable types of plants that might appear under the Sacaton conditions. The result was a marked improvement in average fruitfulness and in the quality of the fiber as compared with the 1908 field. The same method of "bulk selection" was repeated in 1909. It will be interesting to compare the performance of this second generation of bulk selections with that of carefully selected varieties and strains derived from single individuals, which will also be tested on a field scale at Sacaton in 1910.

METHODS OF SELECTION.

The breeding methods employed have been very simple. At the outset all the plants in the test field were examined, and those individuals which were most fruitful, ripened earliest, and had the largest bolls and the best fiber were given numbered tags and were picked separately. The seed cotton from these plants was then carefully compared in the laboratory and the final selection of the most promising individuals was made.

The following year the seed from each of these selections was planted in a progeny row, and each row was marked with the number of the corresponding selection. When the bolls began to open in the fall the rows were carefully worked over, and the best individuals were selected. This process has been continued year after year.

As the work developed, the methods were improved. Latterly more importance has been attached to the "projected efficiency" of the individual selections as shown by the greater or lesser degree of uniformity in the good qualities of their progeny. It is now the practice to begin the work of selection each year by a general survey and comparison of the progeny rows as units. As a result, many of the rows can be rejected at once, either because the plants show too much diversity or because their average fruitfulness, length of lint, and other qualities are inferior. Further consideration is given to only those rows which show a high degree of uniformity and in which at least a majority of the individuals are desirable in all essential qualities.[a] The best individuals in the superior rows are then selected by careful comparison in the field, the branching habit and productiveness of the plants and the size of the bolls being noted and the lint from a number of bolls on different parts of the plant being combed out and examined in respect to length, strength, and general quality.

Evidence has accumulated to the effect that the type of branching of the plant is one of the most important characters to be considered in making selections. Plants which bear a large proportion of the bolls on the fertile branches of the main stem, with a corresponding reduction in the size of the "limbs,"[b] are to be preferred because

[a] An exception should be made to this rule in the case of strikingly superior individuals which are so distinct as to warrant the belief that they are mutations. Such individuals should be retained even if the rows in which they occur are otherwise inferior, in view of the generally admitted tendency of mutations to be prepotent.

[b] The distinction between the fertile branches and the "limbs," or large vegetative branches (which in Egyptian cotton are produced only at a few of the lowest nodes of the main stem), is well expressed by Mr. O. F. Cook in Bulletin 156 of the Bureau of Plant Industry, p. 29: "The branches of the cotton plant are of two definitely different forms. Fertile branches are horizontal or drooping.

they are much easier to pick and because the ripe bolls are held up better and escape contact with dust and mud. The ability to develop fruiting branches at low nodes of the axis—in other words, to set a "bottom crop"—is a desirable character, being an important factor in great fruitfulness. The size of the bolls must be considered, not only because large bolls make picking easier, but because this character is intimately associated with length of fiber.[a] It was discovered last year that an examination of the breeding rows several weeks before the bolls begin to ripen is exceedingly helpful, since it is much easier at that period to compare the different rows in respect to type of plant and amount of diversity. The percentage of contamination that has resulted from previous crossing with other types is especially easy to determine at this early stage.

The seed cotton from the preliminary selections made in the field is picked separately, and the fiber is carefully examined and compared on the seed in the laboratory. The seed cotton from each plant is then ginned, and the color of the resulting fiber is determined by matching with imported samples of the different Egyptian varieties.[b] The average amount of fuzz on the seeds is also recorded after ginning. By a careful comparison of the field notes on productiveness, earliness, vegetative characters of the plants, and size of the bolls with the results of the examination of the fiber in the laboratory, the final choice is made of the selections to be retained for planting in progeny rows the following year, and the rest are discarded. The more promising types are tested on a field scale by planting in differ-

Each joint bears a fruit bud, and the internodes are twisted to bring the buds to the upper side. Sterile branches, or 'limbs,' are upright or ascending, with long straight joints and no fruit buds. The sterile limbs are to be thought of as subdivisions of the main stalk and have the same function. Like the main stalk they can produce other branches which are fertile, but are themselves unable to set any flowers or fruits."

[a] Mr. O. F. Cook has called attention in Bulletin 159 of the Bureau of Plant Industry, p. 45, to the existence of this correlation between the length of the boll and the length of the fiber. The writer has observed that in Egyptian cotton, although extremely long, narrow bolls sometimes contain inferior fiber, very short, rounded bolls are never correlated with long lint.

[b] Mit Afifi has the most deeply colored fiber. A comparison of the imported sample of this variety, which has been used as a standard, with the hand-painted specimens of color tints given in Ridgway's "Nomenclature of Colors" (Boston, 1886) shows the color of this sample to be very nearly intermediate between "cream-buff" and "pinkish-buff"; Nubari is somewhat lighter colored, corresponding very nearly with the "cream color" of Ridgway; Jannovitch fiber is much lighter colored than Nubari and may be described as of a very pale tint of cream color; Abbasi fiber is white, tinged with cream. To conform with commercial usage, however, the terms "brown" (Mit Afifi), "light brown" (Nubari), "cream colored" (Jannovitch), and "white" (Abbasi) will be used in this paper.

ent localities the mixed seed from the unselected plants in the progeny rows. The degree to which the type maintains its uniformity and desirable qualities of plant and fiber when grown in large fields, especially if at different localities affording a considerable diversity of climatic and soil conditions, is, of course, the final measure of its agricultural value.

The types represented by progeny rows in the breeding nurseries at Yuma and Sacaton in 1909 were designated by the following numbers: 300, 301, 310, 320, 330, 340, 350, 360, 361, 362, 363, 370, 380, 382, 383, and 390. Each of these numbers is that of an individual selection made at Yuma in 1907 and of the corresponding progeny row grown at Yuma in 1908. All types the numbers of which belong to the same decade (as 300 and 301, 360 to 363, etc.) are closely related, having been derived from the same individual plant selected at Yuma in 1906. All types numbered from 300 to 340, inclusive, came from one individual selected in the field at Carlsbad, N. Mex., in 1902, and all those numbered from 350 to 390, inclusive, are derived from several individual selections made in the breeding nursery at the same place in 1905.[a]

The progenies of numerous individual selections in each of the above types were grown on the "plant-to-a-row" system in the breeding nurseries at Yuma and at Sacaton in 1909. Strain No. 361 and the Yuma variety (No. 382) were tested on a field scale near Yuma, seed from the unselected plants in the respective progeny rows of 1908 having been used for these plantings. Selections from the progeny rows of the following seven types have been planted in the breeding nurseries of the present year (1910) at Yuma and Sacaton: Nos. 301, 310, 360, 362, 370 (the Somerton variety), 382 (the Yuma variety), and 390.

Heretofore the various progeny rows of all the types represented have been grown side by side in the breeding nurseries, with no attempt to isolate one from another. Even under these conditions most of the rows in 1909 showed a definite unity of type. This indicates a strong tendency to prepotency in the characters of several of these types, for in Arizona the Egyptian cotton generally crosses very freely even with other species when grown near by, and a high percentage of hybrids results.[b] Hereafter, in order to prevent, if possible, any

[a] Owing to an accident to the stakes at the heads of most of the rows in the breeding nursery of 1905, the detailed records of the earlier ancestry of strains 350 to 390 were lost, but they are all descended from the same stock of imported Mit Afifi Egyptian seed that was grown at Carlsbad in 1902.

[b] Owing to the fact that plats of Upland varieties were grown in the neighborhood of the breeding rows of Egyptian cotton at Yuma in 1907, many of the progeny rows in 1908 contained a high percentage of hybrids. In one row there were as many as 25 per cent of first-generation Egyptian-Upland hybrids.

contamination due to intercrossing of the different stocks, the progeny rows of each of the most promising types will be isolated, as far as practicable, from all cotton of different ancestry.

The three most promising types that have so far been developed in the course of this breeding work are described in detail in the following pages. The remaining types either appear less promising or have not yet been sufficiently tested.

THE YUMA VARIETY.

Type No. 382, here designated the "Yuma" variety, is upon the whole the most promising that has so far been developed in this breeding work, and is the one which has been most thoroughly tested on a field scale. In 1909 a field of 4¼ acres near Yuma, Ariz., was planted to this seed, and a high degree of uniformity was noted in the characters of the plants, which were very productive and had large bolls with lint of good quality. Seed of the Yuma variety was planted in 1910 at all localities where experiments with Egyptian types of cotton were undertaken, in order to test its power of retaining its desirable qualities under a variety of conditions of climate and soil.

HISTORY OF THE VARIETY PREVIOUS TO 1909.

The progenitor of the "Yuma" variety was a plant selected in the breeding nursery at Carlsbad, N. Mex., in 1905. It was derived from the stock of Mit Afifi Egyptian seed planted at Carlsbad in 1902, from which all the other types described in this paper are likewise descended. In the progeny row grown at Yuma, Ariz., in 1906 from the Carlsbad selection an individual was selected which was characterized by high productiveness, very large bolls, nearly smooth seeds, a high percentage of lint (32 per cent), and fiber that was very satisfactory in length, strength, and fineness. The progeny plants of this selection in 1907 were of excellent average quality. One of the selections, No. 382, from this progeny row was the immediate progenitor of this variety. It was a very productive plant, with large, long-pointed bolls, and its fiber was silky and lustrous, very strong, and more than 1½ inches in length.[a] The lint percentage (27) was considerably lower than that of its progenitor in 1906.

The amount of crossing which takes place under these conditions in Arizona seems far in excess of what has been observed by most cotton breeders in the eastern United States. It can doubtless be attributed to the unusual abundance of wild bees and other flower-visiting insects in the cotton fields during the summer and early fall.

[a] Measurements of length of fiber are copied from the score cards of the year the sample was grown. It is probable that the length was somewhat too favorably estimated previous to 1908, the earlier practice having been to give the

The progeny row in 1908 from selection No. 382 was remarkably uniform in the characters of the plants, bolls, and fiber.[a] The plants were characterized by great productiveness and by a habit of growth (Pl. I, fig. 2) that distinguished this row from all the other progeny rows in the nursery. They had a tall, stout main stem, which generally greatly surpassed the limbs and bore an exceptionally large proportion of the bolls. The bracts of the involucre were very large and the bolls were long and pointed. The seeds were generally nearly smooth. The average length of fiber equaled or exceeded that of any other of the 1908 progeny rows, and the length throughout the row was fairly uniform. The seed cotton from all the unselected plants in this row was picked and ginned together. As measured by Mr. John A. Walker,[b] the resulting lint ranged from $1\frac{1}{4}$ to $1\frac{3}{8}$ inches in the first picking, $1\frac{3}{8}$ to $1\frac{7}{16}$ inches in the second, and $1\frac{7}{16}$ to $1\frac{1}{2}$ inches in the third picking. In respect to fineness, Mr. Walker classed the lint from the first two pickings as "fine" and that from the third picking as "strictly fine and silky." He found the strength to be "fair" in the first picking and "extra" in the second and third, but in all three pickings the strength was slightly uneven. The color of the lint from all the pickings was light brown.

Twenty individual selections were made in this row, and the seed cotton from each was carefully compared. Although the fiber was generally of high quality, there was much diversity among the different plants and even on the same plant, especially as between the first and the third pickings. In 13 of these plants the fiber had the same color as imported samples of the Jannovitch variety (see footnote *b*, p. 11), in 4 plants the color was intermediate between Jannovitch and Nubari, in 1 plant the fiber was nearly as brown as Nubari, and in another nearly as white as Abbasi. The maximum length of fiber in the 20 selections ranged from $1\frac{5}{16}$ to $1\frac{11}{16}$ inches, in 16 plants the length did not fall short of $1\frac{3}{8}$ inches, in 7 plants none of the fiber was shorter than $1\frac{7}{16}$ inches, and in 2 plants the minimum

fibers a decided pull in straightening them out before measuring them. During the last two years the fibers have been merely smoothed out, without applying tension. It is therefore probable that the deterioration of the progeny of many of the selections which is indicated by length of the fiber shown on the score cards is apparent rather than real. It is believed that the method now followed gives a better idea of the length as usually estimated commercially on samples of ginned cotton; error, if any occurs, is in the direction of too great conservatism.

[a] This row contained only 4 per cent of first-generation Egyptian-Upland hybrids, as compared with 6 to 25 per cent in eleven other rows in the breeding nursery. The small percentage of hybrids in row 382 indicates a high degree of prepotency in this type.

[b] An expert grader of Egyptian cotton, employed by the Bureau of Plant Industry to classify the lint from the different experimental plantings in Arizona in 1908.

length was 1½ inches. The variation in length on the same plant was generally considerable, especially as between the first and the third pickings. The fiber was uniformly silky and very fine, especially in the later pickings. In nearly all plants the strength was satisfactory, and in 7 out of the 20 it was highly so. The percentage of lint varied considerably, having been only fairly good on 8 out of the 20 plants, while on the other 12 it was more satisfactory. In 10 out of the 20 selections the seeds varied from nearly smooth to partly covered with fuzz, in 5 they were nearly smooth, and in the other 5 they varied from nearly smooth to completely fuzzy. The third picking almost always showed a higher percentage of nearly smooth seeds than did the first.

BREEDING EXPERIMENTS IN 1909.

The seed from 14 of these selections was planted in 1909 in progeny rows, 8 at Yuma and 6 at Sacaton. When inspected by Mr. Argyle McLachlan on July 6, there was considerable diversity in 3 of the 8 rows at Yuma, although the foliage type (large, thick, dull-colored, generally three-lobed leaves) was fairly uniform in all. In one row no evident hybrids were found, while in the other rows 2 to 6 per cent of the plants were hybrids and were rogued out. In September the tendency to develop a stout main stem greatly overtopping the limbs was found to be much less pronounced than in progeny row No. 382 of 1908. The plants were generally productive and early ripening, with long spreading or drooping fruiting branches well furnished with bolls. The bracts were large, the bolls large and taper pointed, and the seeds generally partly covered with fuzz.[a] The color of the fiber was generally about that of imported Jannovitch, but was frequently a deeper shade of brown. An unfavorable character was the readiness with which the ripe seed cotton dropped from the open bolls, a peculiarity which necessitates frequent picking. In 4 of the 8 rows at Yuma no selections were made, the fiber having been uniformly short. In fact, none of the rows averaged nearly as good in length of fiber as did the progeny row of 1908 in which their progenitors were selected.

In the 6 rows at Sacaton the plants were very similar in habit, foliage, shape of bolls, productiveness, early ripening, and fiber characters to those at Yuma. One row contained no recognizable hybrids, but from each of the other rows 1 to 5 hybrids or otherwise aberrant individuals were rogued out on August 3. Two of these rows were later discarded, the fiber being uniformly too short to warrant making selections.

[a] There is a general tendency to an increased development of fuzz on the seeds in Egyptian cotton grown for several generations in the Southwest.

Individual selections of the Yuma variety were made in 1909 in 4 of the progeny rows at Yuma and in 4 of the rows at Sacaton, the total number of selections being 16 at Yuma and 23 at Sacaton. In addition to these, 32 individual selections were made in the large field planted to this variety at Yuma, which is described in the following paragraphs. The seed of these selected plants is being grown in progeny rows at Yuma and Sacaton in 1910.

FIELD TEST IN 1909.

Seed from the unselected plants in progeny row No. 382, grown at Yuma in 1908, was picked together and was used in 1909 for planting a field of 4¼ acres in the Yuma Valley. The soil was a rather light loam, and although probably as uniform as could be found in any area of equal size in that locality, there was sufficient difference in soil texture in different parts of the field to cause certain spots to dry out more rapidly after irrigation. The plants in these spots were smaller, the leaves smaller and lighter colored, the flowers opened earlier, and the bolls were generally smaller and opened earlier than elsewhere in the field. The lint was also generally shorter, coarser, and weaker on the plants growing in these spots.

From June 17 to June 22 this field was carefully inspected by Mr. Argyle McLachlan, who rogued out about 2 per cent of the total number of plants as being hybrids or otherwise conspicuously aberrant. On July 24 the field was again carefully examined by Mr. McLachlan and the writer: the plants then appeared remarkably uniform in branching habit, foliage, and other characters. Upon closer examination about one-half of 1 per cent of the plants were found to give indications of hybrid origin or were otherwise aberrant, and these were removed. As the result of these two roguings, therefore, not more than 2½ per cent of the entire stand of plants were found to be appreciably different from the type of the variety. This indicates a very satisfactory degree of uniformity and also a high degree of prepotency, since the progeny row of 1908, which furnished the seed for planting this field, was situated among rows of very different types, in some of which there was a high percentage of hybrids with Upland varieties. (See footnote *b*, p. 12.) Such diversity as was exhibited later in the season by the plants that remained after the second roguing seemed to be well within the limits of individual fluctuation in a "pure" type.

The total yield from this field of 4¼ acres was 7,390 pounds of seed cotton, or 1,740 pounds per acre. On the basis of an average lint percentage of 27.5 [a] this is equivalent to a yield of slightly above 475 pounds of fiber per acre.

[a] A 25-pound sample of seed cotton from the first picking yielded 29 per cent of lint, an equal weight from the second picking 30.4 per cent, and an 85-pound

The relatively low percentage of lint given by the acclimatized Egyptian cotton as compared with the percentages reported in Egypt and those obtained during the earlier years of the acclimatization work in the Southwest is largely explained by an observation made by Mr. McLachlan, who finds that the delinted seeds are considerably larger and heavier in the acclimatized types as now developed. Mr. McLachlan found that imported Mit Afifi seed cotton gave a lint percentage of 33 to 35 and that the delinted seeds weighed only 10 grams per 100. The acclimatized Yuma variety, which gave only 27.5 per cent of lint, had seeds weighing 13 grams per 100. If the seeds had weighed no more than imported Mit Afifi seeds the lint percentage of the Yuma variety would have been 33 (a satisfactory percentage for Egyptian cotton) instead of 27.5. Evidently, therefore, no actual diminution in the quantity of lint on the individual seeds has taken place during the process of acclimatization.

CHARACTERS OF THE PLANTS AND FIBER.

The distinctive features of most of the plants in this field were the same as those of the select progeny rows of the Yuma variety as previously described. The plants (Pl. I, fig. 2) were large and showed a strong tendency to develop a stout main stem surpassing the limbs in height and to produce and retain their fruiting branches well toward the base of the main stem and larger limbs.[a] The fruiting branches were long and spreading or drooping and bore numerous bolls. The

sample from the third picking 27.2 per cent, giving an average for the three pickings of 29 per cent. But since another sample of 50 pounds of seed cotton made up of equal weights from each of the three pickings yielded only 26 per cent of lint, it is deemed fair to take 27.5 per cent, the average of these two results (29 and 26), as the closest possible approximation to the average lint percentage for the entire product from this field, very little of the total having been ginned at this writing.

[a] Mr. Argyle McLachlan early in the summer made a special study of the plants in the 4-acre field with respect to fruiting branches. He found that the first fruiting branch was developed at the ninth to fourteenth node from the base of the stem as compared with the thirteenth to seventeenth node in a planting of imported seed of the Mit Afifi variety. On thirty representative plants from different parts of the field the average lowest node at which a fruiting branch developed was the tenth. It has been pointed out by Mr. Cook that ability to develop fruiting branches at low nodes of the stem, and hence to set a "bottom crop," must considerably increase the earliness and yield of a cotton plant.

The type of plant characteristic of the Yuma variety is described in Mr. McLachlan's report as follows: "The plants are 6 to 8 feet tall with a leading main stem, 5 or 6 vegetative branches nearly as long as the axis but loaded with fruit and consequently spreading at an angle of 50 to 60 degrees, and above them on the axis pendent fruiting branches—a plant of symmetrical, broad-spreading, inverted-kite shape."

leaves were large, comparatively dull green, and usually three lobed. Even when five lobed the leaves were considerably longer than broad, owing to the great length of the middle lobe. The bracts of the involucre were exceptionally large and more or less connate at the base, and the bolls were long and taper pointed (Pl. III). The bolls opened early and completely and there was a somewhat marked tendency to drop the ripe seed cotton. The seeds were generally large for an Egyptian type of cotton and bore a greater amount of fuzz than is usually the case with seed of Mit Afifi cotton as grown in Egypt. The fiber was of fair length (ranging from $1\frac{1}{4}$ to $1\frac{7}{16}$ inches, averaging probably $1\frac{3}{8}$), of satisfactory strength and fineness, and of a pale-brown color, intermediate between that of the Nubari and that of the Jannovitch varieties, as represented by samples imported from Egypt. (See footnote *b*, p. 11.)

The strength and fineness of the lint were tested by Mr. L. H. Dewey, in charge of Fiber Investigations, the tests having been made on three samples of the bulk cotton from unselected plants in the general field. Two of the samples were from the second picking only, while the third sample was made up of equal parts from the first, second, and third pickings. Fiber ginned from the mixed seed cotton of the unselected plants in one of the progeny rows of this variety at Sacaton was also tested. The results of the tests were as follows:

TABLE I.—*Strength and diameter of fiber of the Yuma variety of acclimatized Egyptian cotton grown at Yuma and at Sacaton, Ariz., in 1909.*

Sample.	Breaking strength.		Diameter.	
	Average.	Variation.	Average.	Variation.
Field at Yuma:	*Grams.*	*Grams.*	*Microns.*	*Microns.*
Second picking only	6	4 – 9.5	24	18.5–30
	7	4 –11	24.5	19 –30
First three pickings, equally mixed	5.5	4 – 8.5	27	22.5–33.5
Progeny row at Sacaton	7.3	4.5–11	25.3	22.5–33.5

PERFORMANCE OF NEARLY RELATED TYPES.

Tests made in 1909 of two other types (Nos. 380 and 384), closely related to the Yuma variety (No. 382) are of interest as showing the general excellence of this group. Both of these types are derived from the same individual selection of 1906 which was the progenitor of the Yuma variety. The progenitor of each was an individual selection made in the same progeny row of 1907 in which plant 382 was selected. The progenies of the two selections of 1907 were grown in rows in the breeding nursery at Yuma in 1908, and the bulk seed from the unselected plants in each of these rows was used for the plantings in 1909. One of these types (No. 384) was planted

near the town of El Centro, in the Imperial Valley, California. The plants were very uniform in branching habit and foliage and showed only Egyptian characters, but one aberrant individual having been found among the fifty or more plants in this plat. The fiber was long, silky, and very strong—the best fiber of the Egyptian type produced in the Imperial Valley in 1909. The other type (No. 380) was planted in a test row at Yuma. The plants throughout the row were productive and had long, pointed bolls and large bracts similar to those of the Yuma variety. The seeds were generally smooth; the fiber averaged 1⅜ inches in length and was silky, very strong, and light colored.

PROBABLE MUTATIVE ORIGIN OF THE YUMA VARIETY.

The "Yuma" variety, type No. 382, was derived from imported seed of the Mit Afifi Egyptian variety. Most of the strains which have descended from the same original lot of seed are still typically Mit Afifi in all their characters, as was evident from comparison with plants grown from newly imported seed of that variety in 1908 and 1909. Nevertheless, this particular type now shows little resemblance to the parent variety. In the color of the lint it resembles more nearly the Jannovitch variety. It is especially remarkable for the long, taper-pointed bolls (Pl. III), which are much like those of the Abbasi variety and are in marked contrast to the short, blunt bolls of typical Mit Afifi (Pl. II). The manner of growth of the plants, the characters of the foliage, and the large involucre bracts are also diagnostic. The vegetative characters and the peculiarities of the seed and fiber have recurred with conspicuous regularity wherever seed of this variety or of nearly related types has been planted. The distinctiveness of the characters and their remarkable uniformity indicate that the variety originated as a mutation.[a] The history of such Egyptian varieties as Abbasi and Jannovitch, which are reported in Egypt to have developed from the widely grown and older Mit Afifi variety, makes it altogether probable that

[a] The peculiar branching habit and foliage of the plants were not especially noticed until 1908, when progeny row No. 382 was observed to stand out very distinctively from all other rows in the breeding nursery. Yet the large size of the bolls was noted as early as 1906 in the individual selection of that year, from which this variety is descended. This, together with the close resemblance in the characters of the related type No. 380 (descended from the same individual selection of 1906 which was the progenitor of the Yuma variety), indicates that the mutation occurred at least as long ago as 1906. The incompleteness of the records for the earlier years of this breeding work makes it impossible to determine whether the actual mutation occurred earlier than 1906. It is possible, although not probable, that it was present as an admixture in the Mit Afifi seed imported from Egypt with which the work was begun in 1902.

they originated as mutations from that variety in the same manner as the Yuma variety in this country.

THE SOMERTON VARIETY.

Type No. 370, here designated the "Somerton" variety, is remarkable for the sharply defined characters of the plants and bolls, and is like the Yuma variety in the great uniformity manifested in these respects. It has not yet been adequately tested on a field scale, but the progeny rows grown at Yuma and at Sacaton in 1909 showed it to be a very distinct and definite type. It is being tested in field plantings in 1910 in comparison with the Yuma variety.

HISTORY OF THE VARIETY PREVIOUS TO 1909.

The ancestry of the Somerton variety was similar to that of the preceding down to the year 1905, when the individual plant selection from which the Somerton variety is derived was made in the breeding nursery at Carlsbad, N. Mex. This plant was fairly productive and very early ripening and had small bolls and smooth seeds well covered with lint (percentage, 33). The fiber was fairly uniform in length, with an average of fully 1½ inches; it was brown in color, strong, and very fine. In the 1906 progeny row at Yuma planted with seed grown from this plant, the selected individual which was the progenitor of the Somerton variety was a small, fairly well-shaped, very productive, and early-ripening plant which had medium-sized bolls and smooth seeds well furnished with lint (percentage, 30.5). The fiber was 1½ inches long, very uniform, light brown in color, strong, and very fine. The 1907 progeny row from this plant was characterized by exceptionally early ripening. One of the individual selections made in this row, No. 370, was the immediate progenitor of the variety. It was an extremely productive plant, but the percentage of lint was only 26.5. The bolls were large[a] and the fiber was more than 1½ inches in length, uniform, fine, fairly strong, and cream colored.

Progeny row No. 370 contained in 1908 only 1.5 per cent of hybrids, a remarkably small proportion as compared with most of the other rows in the breeding nursery that year. (See footnote *b*, page 12.) The plants in this row were large and very productive, with a well-developed main stem surpassing the longest of the limbs. The latter were spreading or ascending. The bolls were large and

[a] It will be noted that while the 1905 selection had small bolls and the 1906 plant only medium-sized bolls, the 1907 progenitor of this variety had large bolls. While the bolls were increasing in size from year to year, the percentage of lint was diminishing from 33 per cent in 1905 to 30.5 per cent in 1906 and 26.5 in 1907. (In regard to the decreased lint percentage, see p. 17.)

remarkably sharp pointed. The seed cotton from the unselected plants in this row was picked and ginned together. The resulting lint was light brown in color; that from the first two pickings was classed by Mr. John A. Walker as "fine and strong" and that from the third as "strictly fine, silky, and extra strong." In length of fiber the first picking averaged $1\frac{3}{8}$ inches, the second ranged from $1\frac{3}{8}$ to $1\frac{7}{16}$ inches, and the third picking ranged from $1\frac{7}{16}$ to $1\frac{1}{2}$ inches. The excellent luster of the fiber in this row was noted in the field.

The seed cotton from the ten individual selections of 1908 was carefully compared. In seven of these the fiber was a little lighter colored than imported Nubari cotton, in two the fiber was slightly darker than imported Jannovitch, and in one the fiber was the same color as Jannovitch. The extreme range of length among these ten selections was from $1\frac{1}{4}$ to $1\frac{5}{8}$ inches, but the fiber was generally at least $1\frac{7}{16}$ inches long. The average strength was inferior to that of the selections from most of the other progeny rows of 1908. The general appearance of the fiber was very similar in the ten selections and indicated a distinct and uniform type. There was a strong tendency to smooth seeds.

EXPERIMENTS IN 1909.

Eight of the selections from progeny row No. 370 of 1908 were grown in progeny rows in 1909, six at Yuma and two at Sacaton. The rows at Yuma when inspected by Mr. McLachlan on July 6 showed a higher degree of uniformity and a more distinctive type of plant than any other group of progeny rows in the breeding nursery. Only two of the rows showed any trace of contamination; one contained a single probable hybrid and another had two suspicious-looking plants. The plants were bushy, large in diameter, with five to eight limbs nearly as long as the main stem, the internodes of which were unusually short. The leaves were exceptionally large and were usually broader than long. They were five lobed, with deep clefts between the lobes.[a] On July 23, when first inspected by the writer, the plants in all the rows had an exceptionally vigorous appearance and were distinguished by the unusually bright green color of the foliage. The two progeny rows at Sacaton, inspected August 3, showed the same type of plant and the same high degree of uniformity as the rows at Yuma. There were no obvious hybrids and only one suspicious-looking individual in each row.

On September 23 the plants in the six rows at Yuma had grown very large and were ripening late. The fruiting branches were set well toward the base of the plant and were well furnished with bolls.

[a] A somewhat similar habit and type of foliage characterized the plants grown at Yuma in 1909 from imported seed of the Nubari variety.

The seeds were generally smooth and rather poorly furnished with lint.[a] Individual selections were finally made in only two of the rows, the fiber in the other rows being too scanty and also inferior in length. Numerous selections were made in the two rows at Sacaton, in both of which the plants were characterized by high average fertility. The total number of individual selections of the Somerton variety made in 1909 was twelve at Yuma and eighteen at Sacaton.

The seed cotton from all of the unselected plants in one of the progeny rows at Sacaton was picked and ginned together. The lint was light brown, corresponding in color with imported fiber of the Nubari variety. The strength and diameter of the fiber were tested by Mr. L. H. Dewey, who reported the average breaking strength as 6.3 grams (variation 3.6 to 11.5 grams) and the average diameter as 23 microns (variation 18.7 to 30 microns). This diameter indicates a finer fiber than is shown by the fiber tests of the Yuma variety as reported in Table I (p. 18).

Seed from the unselected plants in progeny row No. 370 of 1908 was planted in 1909 at Yuma, Ariz., and at Brawley, in the Imperial Valley, California. In the small planting at Yuma the plants were of good average fertility, with generally large bolls and smooth seeds. The fiber was satisfactory in length, reaching $1\frac{3}{8}$ inches on many plants and falling below $1\frac{1}{4}$ inches on hardly any. It was of good strength and medium fineness. In the 1-acre field planted with this seed at Brawley the plants were very uniform in appearance, and, with the exception of four hybrid individuals, showed only pure Egyptian characters. The fruiting branches, which were well furnished with bolls, were developed at low nodes on the stem. The bolls were large.

CHARACTERS OF THE PLANTS AND FIBER.

The Somerton variety as exemplified in the progeny rows at Yuma and Sacaton in 1909 is characterized by a great spread of branches, numerous long limbs, and long fruiting branches which are developed well toward the base of the plant and bear numerous bolls. The plants at about the time they begin to blossom have a symmetrical, rounded, bushy appearance and are exceedingly leafy. The large leaves are of a brighter green color and of softer texture than in the Yuma variety. They are usually five lobed and broader than long, while in the Yuma variety they are generally three lobed and considerably longer than broad. The bolls (Pl. IV), which resemble

[a] The average percentage of lint obtained by ginning the seed cotton from the thirty individual selections of the Somerton variety made at Yuma and Sacaton was 25.1 per cent, as compared with 26.7 per cent for the thirty-nine individual selections of the Yuma variety and 29.9 per cent for the eight selections of strains Nos. 360 and 362.

those of the Abbasi Egyptian variety, are long and taper to an extremely sharp point, sharper than in the Yuma variety. The seeds have a strong tendency to be smooth and are frequently devoid of even the tuft of green or brown fuzz at each end which characterizes the seeds of the Mit Afifi variety in Egypt, while in the Yuma variety the sides of the seeds are usually partly covered with fuzz. The lint is very fine, but its percentage is less than in the Yuma variety. In color it is usually darker, varying from that of the Jannovitch to that of the Nubari variety. It shows about the same range of length as that of the Yuma variety.

PERFORMANCE OF A NEARLY RELATED TYPE.

Seed from another individual selection from the same progeny row of 1907 in which plant No. 370 was selected was grown at Yuma in 1908. Seed from all the unselected plants in the 1908 row was picked together and was used for planting a small plat in the neighborhood of Los Angeles, Cal., in 1909, alongside a similar planting of imported seed of the Mit Afifi variety.[a] The plants made only a small growth, produced comparatively few bolls, and ripened very late. On September 13, when none of the bolls had yet opened, no difference could be detected between the plants from the acclimatized and those from the imported seed, but in the quality of the fiber produced, the acclimatized ultimately proved very superior. The fiber was fine and silky and excelled in strength any other cotton of the Egyptian type grown in the Southwest in 1909. The average breaking strength, as reported by Mr. L. H. Dewey, was 8 grams (variation from 4 to 12 grams), and the average diameter 25 microns. As compared with this the fiber produced by the plants from the newly imported Mit Afifi seed in the same field was decidedly weaker and coarser, its average breaking strength being 6.8 grams (variation from 4 to 14.8 grams) and its average diameter being 30.6 microns.

PROBABLE MUTATIVE ORIGIN OF THE SOMERTON VARIETY.

Like the Yuma variety the Somerton variety is very distinct from the Mit Afifi stock with which this breeding work was begun and shows a high degree of prepotency, as evidenced by the remarkable uniformity which it has maintained notwithstanding abundant opportunities for crossing with other types. These facts give good

[a] This planting near Los Angeles, under the direction of Mr. O. F. Cook, was made to ascertain the effect of very different climatic conditions upon the habit of the plants and upon the expression of diversity in a stock that had been acclimatized in the Colorado River region as compared with newly imported seed. It was realized, of course, that the conditions in that part of California are not favorable to cotton culture on a commercial scale.

ground for the belief that it has originated as a mutation. It is possible that the mutation occurred in 1907, since the breeding records show that the 1905 ancestor of the strain had small bolls and the 1906 ancestor medium-sized bolls. The 1907 progenitor, which was the first recorded as having large bolls, may well have been the original mutant, but unfortunately no detailed description was made of the vegetative characters of this plant. The plants of a nearly related type grown near Los Angeles (p. 23) were so unlike those in any planting of Egyptian types of cotton that has been made in the Colorado River region,[a] that it was impossible to decide whether this stock shares the vegetative characters of the Somerton variety. If it had been grown under similar conditions and had exhibited the same characteristics, ample evidence would have been afforded that the mutation must have occurred at least as early as 1906.

STRAINS NOS. 360, 361, AND 362.

ORIGIN OF THE GROUP.

The group of strains Nos. 360, 361, and 362, like the Yuma and Somerton varieties, was derived from an individual selection made at Carlsbad, N. Mex., in 1905, in a part of the breeding nursery where the numbers of the progeny rows had been lost. The ancestry of the group previous to 1905 is therefore unrecorded except that each strain was derived from the same lot of imported Mit Afifi seed used in beginning the breeding work in 1902, from which all the varieties and strains described in this paper originated. An individual selection in the progeny row from the Carlsbad plant grown at Yuma in 1906 is the common ancestor of this group of strains. The plants representing the progeny of the individual selected in 1906, grown in a row at Yuma in 1907, were noted as being uniformly excellent. Three individual selections of that year, numbered as above, are the direct progenitors of the three corresponding strains.

STRAIN NO. 360.

Selection No. 360 of 1907 was characterized by a satisfactory percentage of lint (30 per cent) and by fiber that was fully 1½ inches long, uniform in length, fine, and of a good brown color, but rather inferior in strength. The 1908 progeny row from this plant contained about 11 per cent of hybrids. The remaining plants were

[a] The plants grown near Los Angeles, both from the acclimatized strain and from imported Mit Afifi seed, were small, and they had few and short limbs; they were conspicuously hairy and had a great deal of red color in the stems and involucres. The bracts were broad, cordate, and deeply toothed. The calyx was distinctly toothed, a character usually peculiar to Upland as distinguished from Egyptian types. The stigmas were exceptionally short.

uniform and were typically Mit Afifi in their characters. They were productive, ripened early, and produced fiber that was distinctly brown in color. The seed cotton from the unselected plants in this row was picked and ginned together. The lint had an average length of 1⅜ inches in the first picking and ranged from 1⅜ to 1½ inches in the second picking. The strength and color were very satisfactory in both pickings. Three individual selections were made in this row, and the seed was planted in progeny rows in 1909, two at Yuma and one at Sacaton. When examined July 6 one of the rows at Yuma contained two and the other four unmistakable hybrid individuals, and there was considerable diversity among the remaining plants. The row at Sacaton, inspected August 3, contained no obvious hybrids, but the plants were generally infertile, and the row was discarded. In September one of the rows at Yuma was decidedly inferior in the average length, strength, and fineness of the fiber, and no selections were made; only one individual selection was made in the other row at Yuma.

The seed cotton from the unselected plants in progeny row No. 360 of 1908 was picked and ginned together and the seed was planted at Holtville, in the Imperial Valley, California, in 1909. The soil was very sandy and the seed was planted late, consequently the yield was small. Nevertheless, many of the plants showed a strong tendency to produce a "bottom crop," developing fruiting branches at low nodes on the stem. On a good percentage of the plants the fiber was satisfactory in length and strength. There was considerable diversity in the appearance and vegetative characters of the plants, and a large number of hybrids and otherwise aberrant plants were removed at the end of July.

STRAIN NO. 361.

History.—Individual selection No. 361 of 1907 was a much more productive plant than No. 360, but otherwise greatly resembled it. The seeds were abundantly furnished with lint, the percentage being 32. The fiber had all the characters of a good Mit Afifi and was very fine, strong, and of a good brown color. The length exceeded 1½ inches and was very uniform. In 1908 the progeny row from this plant contained about 6 per cent of hybrids. It was one of the most uniformly fruitful and early-ripening rows in the breeding nursery. The fiber was of typical Mit Afifi character, and was highly satisfactory in fineness, color, and length, although the uniformity of length was somewhat disappointing. The percentage of lint was good. All seed from the unselected plants in this row was picked and ginned together. Mr. John A. Walker reported on the lint from the first picking that it has a "distinctly brown color, even throughout, showing very little white, giving it a greater resemblance to regular Egyptian

(brown) than anything ginned to date; has also good 1⅜-inch staple, extra strong and silky. Can be regarded as very satisfactory cotton." The second picking apparently contained a somewhat higher percentage of white fiber, but was otherwise similar. A careful examination of the seed cotton from eleven individual selections in this row showed that in color it was slightly lighter than imported Nubari fiber (footnote *b*, p. 11) in all but two plants, in which is equaled the Nubari. The selections were more uniform in their fiber characters than those from most of the other progeny rows of 1908, the uniformity having been especially marked in respect to color, strength, and fineness.

Five progeny rows of strain No. 361 were grown at Yuma in 1909. In all but one of the rows from one to three hybrid plants were found on July 6; otherwise the plants were very similar in all the rows. Unfortunately these five rows were planted in an unfavorable situation close to a row of cottonwood trees; they were consequently so unproductive and the fiber was so short that no individual selections could be made. The fiber showed more color than was exhibited in the progeny rows of any other strain at Yuma in 1909.

Field test in 1909.—The bulk seed from the unselected plants in progeny row No. 361 of 1908 was planted in 1909 in a field of 3 acres near Yuma. On July 27, the evident hybrids having been rogued out early in the season, the field appeared very uniform. The plants were rather strict in habit and did not develop fruiting branches at the lower nodes,[a] which was doubtless chiefly owing to the rather late planting and to lack of water for irrigation at critical times during the summer. For the same reasons the yield from this field was low and the lint was inferior in length and strength to what might have been expected from the undoubted excellence of the stock. In dry places in the field the strength was especially inferior. There was a marked tendency to uniformity in the characters of the plants and fiber, and the percentage of probable hybrids or otherwise aberrant individuals was small. The bolls held the ripe cotton better than was observed with the Yuma variety. The fiber had an excellent color, intermediate between that of Nubari and Mit Afifi (footnote *b*, p. 11). A considerable number of typical plants in this field, distinguished from the average by greater fertility and better lint, were

[a] Mr. Argyle McLachlan found that in fifteen representative plants from different parts of this field the average lowest node of the main stem at which a fruiting branch was developed was the fifteenth, hence not lower than in plantings of imported seed of Egyptian varieties. On the other hand, in thirty representative plants from different parts of the 4-acre field of the Yuma variety the first fruiting branch was developed on the average at the tenth node of the main stem. It should be observed, however, that the latter field was planted three weeks earlier than the field of strain 361.

marked and the seed from these was picked together (bulk selection) for planting a yield-test field in 1910. Ten individual selections were also made by Mr. W. A. Peterson.

STRAIN NO. 362.

Individual selection No. 362 of 1907 was an exceedingly fruitful plant, with a lint percentage of 29. The fiber was typically Mit Afifi in character, had a good brown color, and was very fine in all but the first picking.[a] In length it exceeded 1½ inches and showed a high degree of uniformity. There was considerable variation in the strength, the later pickings being inferior in this respect. The 1908 progeny row from this plant contained 7 per cent of hybrids. The plants were very similar to those in row 361 (see above). They were very productive and well shaped, with fruiting branches nearly to the base of the stem. The bolls, which opened very early, varied somewhat in size, but were generally medium sized for the Mit Afifi variety. The fiber was of characteristic Mit Afifi type, very fine and lustrous, strong, and well colored. There was a decided lack of uniformity in length of fiber, but the average was about 1⅜ inches. The seed from the unselected plants in this row was picked and ginned together. The lint was classed by Mr. Walker as "fine" in the first picking and "strictly fine, silky" in the second picking. The length ranged from 1¼ to 1⅜ inches in the first and from 1⅜ to 1½ inches in the second picking. In both pickings the lint was "wasty." It was "extra strong," but uneven in strength.

Seed cotton from eight individual selections from this row was carefully examined, and proved very similar to that of the selections in row 361. In color the fiber on four of the plants equaled imported Mit Afifi, and on the other four equaled imported Nubari. The length of the fiber on the different plants ranged from 1¼ to 1 9/16 inches, but the average was 1 7/16 inches. The fiber was uniformly very fine and generally strong. The lint percentage was good. The seeds varied from smooth to partly covered with fuzz.

The seed of six individual selections was planted in progeny rows at Yuma in 1909. When inspected on July 6 there were from one to three evident hybrids in all but one of the rows, and there was otherwise considerable diversity in foliage and branching habit. In September the plants in all the rows appeared very similar in type of plant and in the character of the bolls and lint. Eight individual selections were made in the six rows.

[a] It was observed in 1908 that the fiber from the first picking in every lot of cotton grown was coarser and rougher than that from the second and later pickings. This was especially marked in early-ripening types, like No. 362, and was doubtless due to the fact that the bolls opened and exposed the seed cotton to the intense light and dry air long before the first picking was made.

GENERAL CHARACTERISTICS OF STRAINS NOS. 360, 361, AND 362.

The plants of strains Nos. 360, 361, and 362 grown in progeny rows at Yuma in 1909 had an open habit (Pl. I, fig. 1) with a few long, upright, slender limbs nearly equaling the main stem in length; the fruiting branches were long and slender, bearing comparatively few bolls, and generally had a very long basal internode;[a] the foliage rather sparse; the bolls short, rounded, and with a blunt tip (typical Mit Afifi bolls, see Pl. II); the seeds smooth or partly covered with fuzz; and the fiber generally short and strong, fine, and nearly as brown in color as imported Mit Afifi fiber. The percentage of lint was much higher than in the Yuma and Somerton varieties, 25 pounds of seed cotton from the "bulk selections" in the 3-acre field of strain 361 having yielded 31.6 per cent of lint.[b]

These strains constitute a uniform type which shows no marked departure from typical Mit Afifi cotton as grown in Arizona from imported seed, except that the plants are more productive and develop fruiting branches at lower nodes on the stem, open their bolls earlier, and produce lint of better quality. The high degree of uniformity exhibited by the plants in the 3-acre field of strain 361 at Yuma in 1909 indicates a considerable degree of prepotency, since the progeny row which produced this seed in 1908 was situated in the breeding nursery among other rows of very different type, most of which contained numerous mybrids (footnote *b*, p. 12).

IMPORTED SEED OF EGYPTIAN VARIETIES TESTED IN 1909.

As a check on the progress of the acclimatization and selection and in order to compare the amount and kinds of diversity shown by the plants from newly imported seed with that of the acclimatized and selected stocks, seed of the six leading Egyptian varieties (Mit Afifi, Nubari, Jannovitch, Ashmuni, Abbasi, and Sultani) was planted in alternate rows in the Yuma Valley and at Sacaton, Ariz. Larger plantings (one-half acre to 1 acre) of the first four varieties were also made in the Yuma Valley. A plat of imported Mit Afifi was

[a] This rather undesirable branching habit does not appear to be inherent in these strains, but seems to be due mainly to the unfavorable situation of these particular rows, which suffered several times during the season from lack of moisture on account of the competition of a neighboring row of trees. In the row which had the most favorable moisture conditions the plants were much more productive, with fruiting branches developed well toward the base and usually bearing five or six bolls each. In this row the bolls were larger than in the others.

[b] Mr. Argyle McLachlan found that 100 delinted seeds of strain 361 weighed 11.75 grams, while the same number of seeds from a sample of imported Mit Afifi weighed only 10 grams. If the seeds weighed no more than the imported (see p. 17), the lint percentage of strain 361 would therefore have been 35.3 instead of 31.6.

also grown alongside a planting of a select acclimatized stock derived from the same variety at Glendale, near Los Angeles, Cal. (See p. 23.)

The imported varieties differed widely in the amount of diversity shown, this being least in the Mit Afifi and Nubari varieties and greatest in Ashmuni. The Mit Afifi and Nubari varieties showed a high degree of uniformity, indicating that the seed received from Egypt was the result of careful selection in that country. The Mit Afifi, as in all previous plantings of imported seed of that variety, at all places where the comparative plantings were made, showed itself very inferior to the acclimatized and selected stocks in yield, earliness, and quality of the fiber. On the other hand, the Nubari, although by no means equaling the improved strains which have resulted from several years of acclimatization and selection in the Southwest, was decidedly superior in all these respects to any other planting of newly imported seed which has been made in that region. The yield from one-half acre of this variety was 514 pounds of seed cotton, which was equivalent to 290 pounds of lint per acre, the percentage of lint being 28.1.

MISCELLANEOUS EXPERIMENTS IN 1909.

In addition to the plant-breeding experiments and the field tests of acclimatized and imported stocks, a number of other experimental plantings were made near Yuma, Ariz.

Progeny of first-generation hybrids.—Progeny rows of several first-generation Upland-Egyptian hybrids selected in the breeding nursery of 1908 (see footnote *b*, p. 12) were grown. It was observed in 1908 that these first-generation hybrids, when compared with the pure Egyptian plants in the rows in which they occurred, were very superior in fruitfulness, size of bolls, and in the abundance, length, and strength of the fiber. The progenies of the different individuals in 1909 showed considerable difference in the amount of diversity and in the degree in which the characters of the Egyptian or of the Upland parent predominated. None of the plants in any of the rows came near equaling the parent selections in productiveness or in the quality of the fiber. Some of the first-generation hybrid parents had very smooth seeds and others had completely fuzzy seeds. As a rule, the progenies in 1909 showed no uniformity in their inheritance of this character; many fuzzy-seeded offspring were from smooth-seeded parents, and vice versa. An examination of these hybrid progeny rows gave no indication of the likelihood that a superior strain could be developed by this method, and no selections were made in the second generation.

Production of first-generation hybrids.—Under the direction of Mr. O. F. Cook, Egyptian cotton was planted in rows alternating

with various Upland varieties in order to test the possibility of securing in this manner a stock of first-generation hybrid seed for commercial planting.[a] The early flowering of most of the Upland varieties, as compared with the Egyptian, indicated that to use this method successfully it might be necessary to select a late-flowering Upland variety for the alternate plantings or else to plant the Upland cotton later than the Egyptian.

Seed selection.—Another experiment, carried on by Mr. Argyle McLachlan, was the planting in separate rows of the different types of seed selected from various imported and acclimatized lots, in order to determine the possible advantage of sorting by hand cotton seed that has become mixed by hybridization, and thus to eliminate aberrant types before planting, thereby gaining greater uniformity in the crop and reducing the opportunity for further crossing.

Different dates of planting.—Row plantings of a single acclimatized stock were made on successive dates throughout the spring in order to compare the effect of early with that of late planting under otherwise uniform conditions upon the fruitfulness and lint qualities of the plants, and to ascertain the best time for putting in the seed. For various reasons this experiment gave no conclusive results, but the matter is an important one and will be made the subject of further experimentation. All the evidence so far obtained points to the advantage of planting Egyptian cotton in the Colorado River region as early in the spring as the weather will permit.

Seed from different pickings.—Seed from the different pickings of several of the acclimatized stocks was planted in rows in order to determine if possible whether the early or the late ripened seed is the most desirable for planting. Only negative results were obtained, none of the three pickings appearing to give generally better results than either of the others, but it is not considered that this problem has been finally solved.

Irrigation.—The conditions in 1909 with regard to the supply of water for irrigation were so unfavorable that no special experiments could be carried out to determine the best method of irrigating Egyptian cotton. There is no question that the yield, uniformity, and quality of the fiber, especially in respect to length and strength, depend in a high degree upon the manner in which the plants are irrigated. This is considered the most important cultural problem remaining to be solved in connection with the production of this crop in the Southwest.

[a] In a paper entitled "Suppressed and Intensified Characters in Cotton Hybrids," Bulletin 147, Bureau of Plant Industry, United States Department of Agriculture, pp. 15–16, Mr. Cook calls attention to the possible commercial utilization of the superior qualities of first-generation hybrids of Egyptian with Upland cotton.

PRESENT COMMERCIAL STATUS OF EGYPTIAN COTTON IN THE UNITED STATES.

During the latter part of 1909 and the early months of 1910 all types of cotton commanded unusually high prices. The condition of the long-staple cotton market was especially abnormal owing to the operation of a number of independent causes. The advance of the boll weevil in the cotton belt of the South has led to a feeling of uncertainty in the localities which furnish the bulk of our supply of long-staple Upland cotton. Furthermore, the 1909 crop in Egypt was an exceptionally small one, and from all reports the quality of the fiber was unusually poor. Various explanations are offered for the disquieting state of affairs that exists in Egypt. It is widely believed that the construction of the great dam at Assuan, in upper Egypt, and of "high line" canals, with the consequent abundance of irrigating water and increased opportunity for seepage, has resulted in raising the water table throughout the cotton-growing provinces of the Delta to a point that seriously injures the deep-rooted cotton plants.

TABLE II.—*Average prices of Good Fair Egyptian and Middling Upland cottons on the Boston market for each month from January to October, 1909.*[a]

Month.	Average price per pound.		Month.	Average price per pound.	
	Good Fair Egyptian.	Middling Upland.		Good Fair Egyptian.	Middling Upland.
	Cents.	*Cents.*		*Cents.*	*Cents.*
January	17.0	9.9	June	18.5	11.5
February	16.5	9.9	July	19.9	12.9
March	16.0	9.9	August	19.9	12.7
April	16.6	10.5	September	20.2	13.2
May	18.0	11.3	October	22.0	14.4

[a] The average prices of Egyptian and Middling Upland cottons on the Boston and Liverpool markets during the ten years from 1898 to 1907, inclusive, are stated in Bulletin 128, Bureau of Plant Industry, p. 25, tables 4 and 5. Prices during 1908 are discussed in Circular 29, Bureau of Plant Industry, pp. 5 and 6.

TABLE III.—*Average prices of different grades of Egyptian and of Middling Upland cotton on the Boston market for each month from November, 1909, to July, 1910.*[a]

Month and year.	Average price per pound.				
	Egyptian.				Middling Upland.
	Low grades.	Current.	Good grades.	High grades.	
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*
November, 1909	19 -22½	20⅝-23¾	21¾-25½	23 -27½	15 -15⅝
December, 1909	22½-25½	24 -27½	26 -29½	27¾-31	15 -15⅝
January, 1910	24 -26⅝	25⅝-28⅝	27⅝-30⅝	29¾-32½	15 -16⅜
February, 1910	22 -27	26 -32	28⅝-33	31⅜-35½	15 1/16-15 7/16
March, 1910	22½-28½	27½-33½	32½-34½	33½-36⅞	15 7/16-15 9/16
April, 1910	20½-27⅞	23¾-32⅞	28½-33½	31½-36⅞	15 7/16-15 9/16
May, 1910	19⅜-22¾	23½-26½	26¾-30⅜	29⅜-33	15 9/16-15 13/16
June, 1910	17⅜-22⅜	19¾-26½	21⅜-30⅜	22¾-33	14½ -15½
July, 1910	17⅛-20¼	19¼-21¾	20⅜-22¾	21⅜-24½	15½ -16

[a] The prices for each month are the minimum and the maximum of the weekly prices for each grade as quoted in the Commercial Bulletin, published at Boston.

It would be unwise to rely upon a maintenance of the recent very high level of prices. During the ten years from 1898 to 1907, inclusive, the average price on the Boston market of all grades of Egyptian cotton imported was 15.3 cents, as compared with 9.5 cents for Middling Upland. During 1908 the average price of Egyptian cotton on the same market was 18.07 cents, as compared with 11.11 cents for Middling Upland. It should be noted, however, that these prices cover the total quantity of Egyptian cotton imported, much of which belongs to very inferior grades. Fiber of a quality such as experiments have demonstrated can be produced in the Southwest would be expected to command a premium of several cents over the average.

The total imports of Egyptian cotton into the United States during the calendar year 1909 amounted to 72,617,893 pounds, valued at $12,101,000, as compared with 61,511,723 pounds, valued at $11,560,009, in 1908.

CONCLUSION.

In summing up the most important results of the breeding work with Egyptian cotton in 1909, it is noted that the diversity caused largely by crossing with other types of cotton, which in 1908 seemed to seriously threaten the future of the acclimatized stock, has to a great extent disappeared. This is doubtless partly due to the planting of carefully selected types. The most promising of these is apparently a mutation and shows a strong tendency to be prepotent: in other words, to maintain its uniformity even in the presence of opportunity for crossing with other stocks. The application of methods of eliminating hybrids and aberrant individuals before the plants begin to open their flowers which Mr. Cook has worked out as a result of his diversity studies has also greatly contributed to this result.

The breeding work of the past seven years has developed several superior strains and two very distinct varieties which are now ready for testing on a field scale. The two varieties—the Yuma and the Somerton—developed from an imported stock of the Mit Afifi variety, represent a wide departure from the characteristic parent type. In their large, pointed bolls and lighter colored fiber they more nearly approach other Egyptian varieties, which are also believed to be derived from Mit Afifi and probably originated in the same manner as "sports" or "mutations." One of the new strains represents typical Mit Afifi in the shape of its bolls and in the deeper color and other characteristics of its fiber, but is notably superior to the average of that variety, at least as grown in the United States from imported seed. This strain, which was grown last year on a field scale, likewise exhibited a high degree of uniformity.

Experiments in 1909 with these well-marked new varieties indicate that transfer to a new locality having somewhat different climatic and soil conditions does not induce diversity to anything like the extent that results when newly imported seed or mixed seed of different acclimatized stocks is planted in new places. Thus the very distinct Yuma variety, which was first distinguished and very likely originated at Yuma, Ariz., maintained its superior uniformity, productiveness, and distinctive type of plants and of fiber when planted under the decidedly different conditions existing at Sacaton, Ariz., and in the Imperial Valley, California. The equally distinct Somerton variety, which also probably originated near Yuma, maintained its superiority to newly imported seed at Sacaton and at Los Angeles, Cal., although in the latter locality, which represents an extreme departure from the climatic conditions existing in the Yuma Valley, the general appearance of the plants was very different. It is therefore apparent that the difficulties of "local adjustment" or adaptation of an acclimatized strain to the varying climatic and soil conditions of different localities in the region in which the acclimatization has taken place are not likely to interfere seriously with the extensive utilization of selected types possessing a high degree of prepotency such as are described in this paper.

SUMMARY.

Several distinct and promising varieties and strains which have resulted from the acclimatization and breeding experiments with Egyptian cotton in the southwestern United States were tested on a field scale in the Colorado River region in 1909 and gave very favorable results in regard to the quality and uniformity of the fiber produced.

The results of the season's work showed that by planting carefully selected types and by "roguing out" the markedly aberrant individuals early in the summer the degree of uniformity can be attained which is demanded by the market for this class of cotton.

Diversity can be still further controlled and the fruitfulness of the plants maintained by avoiding extremely light and extremely heavy types of soil and by managing irrigation so that the plants are not exposed to alternations of severe drought and excessive moisture.

Samples of the fiber produced in 1909 were submitted to a number of spinners and other experts, who were unanimous in pronouncing them equal in all respects to imported Egyptian cotton of corresponding grades.

Two of the best types (the Yuma and Somerton varieties) are so distinct from the Mit Afifi variety from which they have been derived as to warrant the belief that they are mutations and have originated

in the same manner as Abbasi, Jannovitch, and other superior types which have been developed in Egypt from the Mit Afifi variety.

A third type (strains 360, 361, and 362) resembles Mit Afifi in all characters of the plants, bolls, and fiber, but the plants are much more productive and produce fiber of better quality than those grown in the same region from imported seed. This type is to be regarded as an acclimatized and improved Mit Afifi rather than a new variety.

The Yuma variety was tested in a field of 4 acres near Yuma, Ariz., in 1909, and showed a very satisfactory degree of uniformity in the productiveness and habit of the plants and in the quality of the fiber. It is characterized by a strong tendency to develop a stout main stem greatly surpassing the limbs, and possesses long fruiting branches, long taper-pointed bolls, and strong, silky, cream-colored fiber, averaging about $1\frac{3}{8}$ inches in length.

The Somerton variety resembles the preceding in the length of its bolls and in most of its fiber characters, but the bolls are more sharply pointed, the seeds generally smoother, the percentage of lint smaller, and the plants more bushy, with a greater development of large vegetative branches.

The group of strains Nos. 360, 361, and 362, constitutes a uniform type that is very different from the Yuma and Somerton varieties. The plants are of open habit, with several large limbs nearly equaling the main stem; short, plump, abruptly pointed bolls; and strong fiber of medium length (averaging $1\frac{1}{4}$ to $1\frac{3}{8}$ inches). In color the fiber is almost as brown as that of imported Mit Afifi.

Other more or less distinct types have been developed, but are either less satisfactory or have not yet been sufficiently tested.

Imported seed of the principal Egyptian varieties was planted in 1909 in Arizona in the vicinity of Yuma and at Sacaton. The varieties differed greatly in the amount of individual diversity manifested. None of them equaled the acclimatized stocks in fruitfulness or in quality of the lint.

Progenies of a number of first-generation Egyptian-Upland hybrids were grown near Yuma. The second-generation plants showed excessive diversity of type, but none of them could compare with the first-generation parents in yield or in excellence of the fiber.

The imports of cotton from Egypt into the United States during the calendar year 1909 amounted to 72,617,893 pounds, valued at $12,101,000, as compared with 61,511,723 pounds, valued at $11,560,009, in 1908.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. Fig. 1.—A fertile plant of acclimatized Egyptian cotton of the type characteristic of strains Nos. 360, 361, and 362, with several large ascending vegetative branches nearly as long as the main stem and bearing a considerable percentage of the bolls. Grown near Yuma, Ariz., in 1908. Fig. 2.—A plant of the Yuma variety of acclimatized Egyptian cotton with a tall, stout main stem bearing most of the bolls and with the vegetative branches much reduced. Grown near Yuma, Ariz., in 1908.

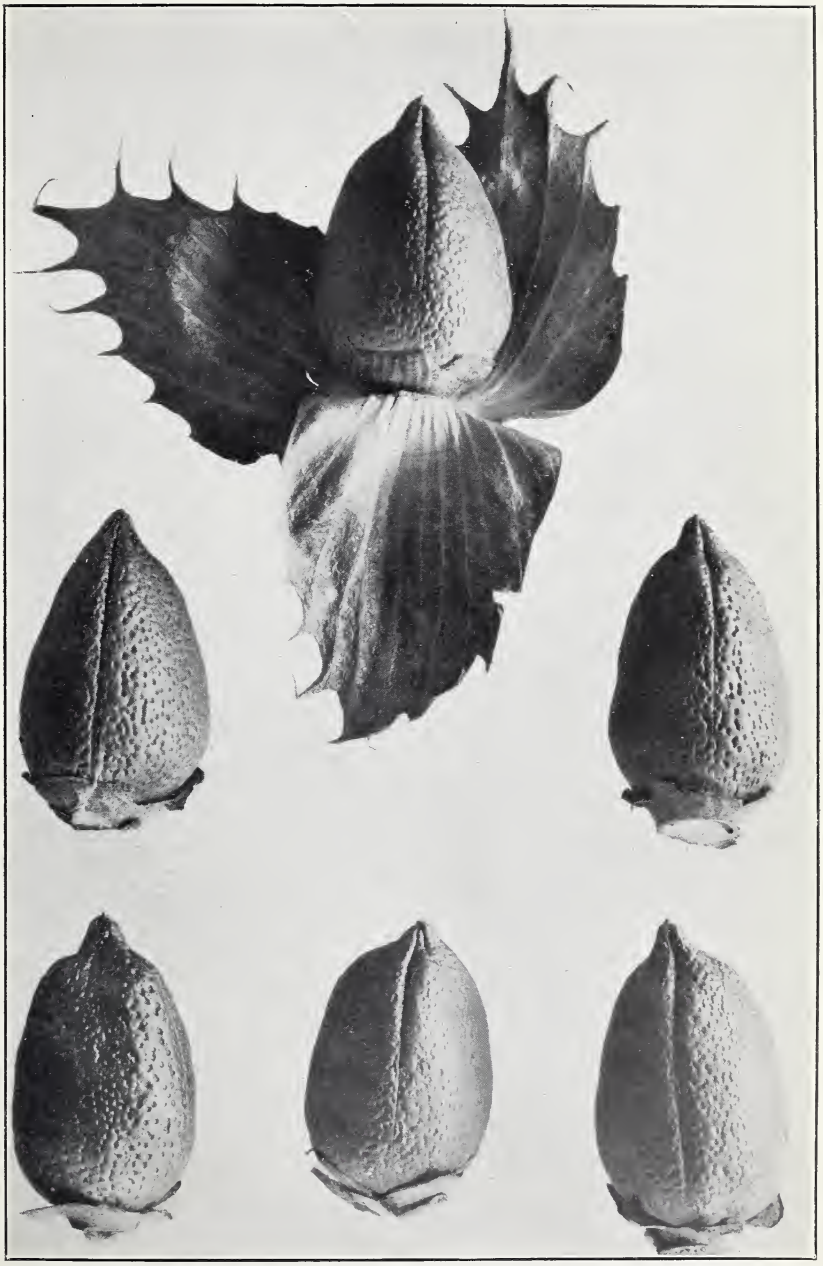
PLATE II. Typical bolls and bracts (natural size) of Mit Afifi Egyptian cotton grown from imported seed near Yuma, Ariz., in 1908.

PLATE III. Typical bolls and bracts (natural size) of the Yuma variety of acclimatized Egyptian cotton grown near Yuma, Ariz., in 1909. Note the larger and more pointed bolls as compared with typical Mit Afifi (Pl. II).

PLATE IV. Typical bolls and bracts (natural size) of the Somerton variety of acclimatized Egyptian cotton grown near Yuma, Ariz., in 1909. The bolls are more sharply pointed than in the Yuma variety (Pl. III).

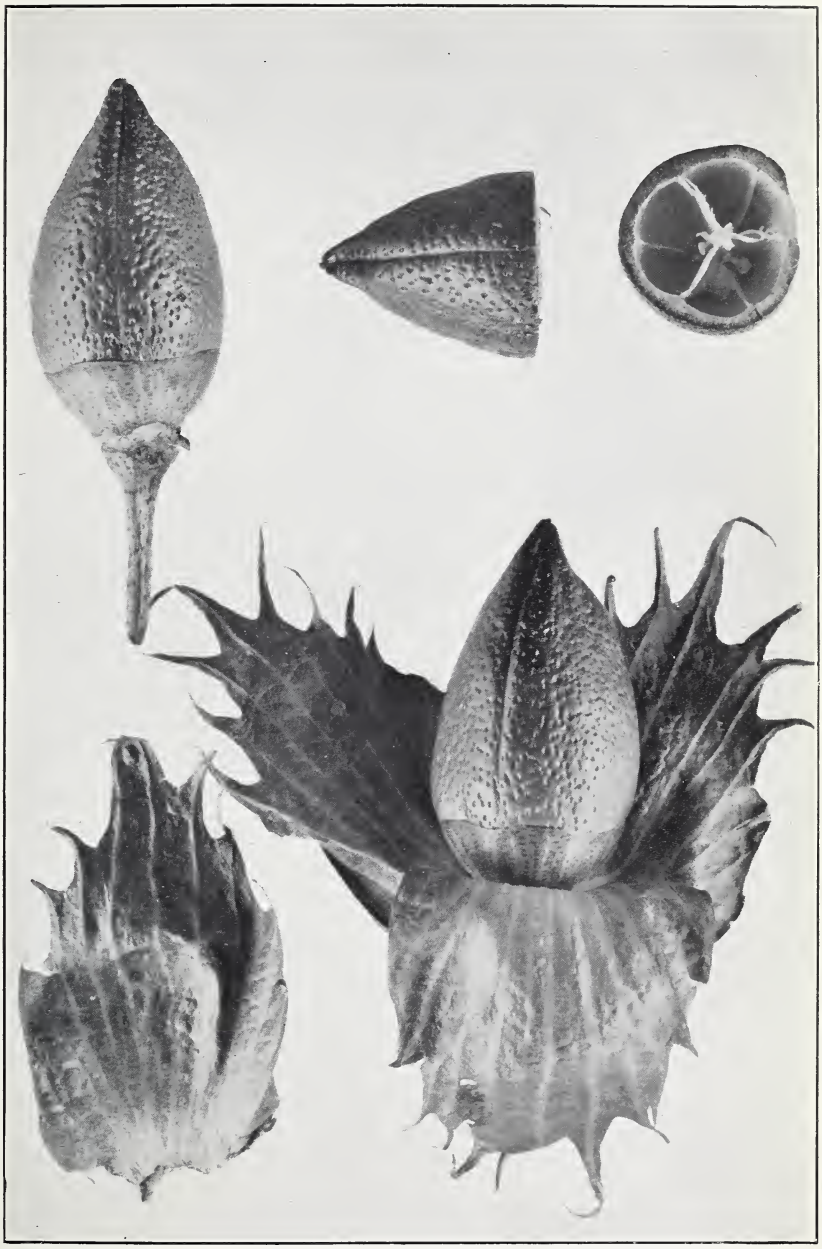
FIG. 1.—A FERTILE PLANT OF ACCLIMATIZED EGYPTIAN COTTON.

FIG. 2.—A PLANT OF THE YUMA VARIETY OF ACCLIMATIZED EGYPTIAN COTTON.



TYPICAL BOLLS AND BRACTS OF MIT AFIFI EGYPTIAN COTTON GROWN FROM IMPORTED SEED.

(Natural size.)



TYPICAL BOLLS AND BRACTS OF THE YUMA VARIETY OF ACCLIMATIZED EGYPTIAN COTTON.

(Natural size.)

TYPICAL BOLLS AND BRACTS OF THE SOMERTON VARIETY OF ACCLIMATIZED EGYPTIAN COTTON.

(Natural size.)

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